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Integrated approach for characterizing and comparing exposure-based impacts with life cycle impacts

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To address hazardous chemicals in consumer products, chemical alternatives assessment (CAA) is an emerging approach combining hazard and exposure assessment with technical and economic feasibility. Life cycle aspects are typically not consistently considered in CAA, but are relevant to avoid decisions that involve burden shifting or that result in only incremental improvement. Focusing in the life cycle impacts on widely accepted and applied impact categories like global warming potential or cumulative energy demand aggregating several impact categories will lead to underestimations of life cycle emissions of potentially harmful chemicals and their proposed replacements. Hence, an assessment framework is required that is able to account for near-field consumer exposure to chemicals in products during and after product use as well as population far-field exposure to chemical emissions to the environment from product-related processes along the product life cycle. We build on a flexible mass balance-based modeling system yielding cumulative multimedia transfer fractions and exposure pathway-specific Product Intake Fractions defined as chemical mass taken in by humans per unit mass of chemical in a product. When combined chemical masses in products and further with toxicity information, this approach is a resourceful way to inform CAA and minimize human exposure to toxic chemicals in consumer products through both product use and environmental emissions. We use an example of chemicals in consumer products to demonstrate how this matrix-based system offers a consistent and efficient way to compare exposure pathways for different user groups (e.g. children and adults) and the general population exposed via the environment. We further compare toxicity-related outcomes with outcomes from other life cycle impacts to compare the relevance of different impact categories for different consumer product classes. Through our examples, we will show (a) how to align assumptions used in different assessment methods in a manner that can avoid contradictory results, (b) to consistently consider and compare all relevant impacts, thereby avoiding burden shifting that could result from disregarding chemical and product life cycles, and (c) to prioritize the most relevant impacts across all life cycle stages, thereby setting the scene for a “life cycle alternatives assessment” (LCAA).